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(11) Publication number: **0 587 290 A2**

(12)

## EUROPEAN PATENT APPLICATION

(21) Application number: **93305968.5**

(51) Int. Cl.<sup>5</sup>: **G06F 15/21**

(22) Date of filing: **28.07.93**

(30) Priority: **30.07.92 US 922210**  
**22.07.93 US 96595**

(43) Date of publication of application:  
**16.03.94 Bulletin 94/11**

(84) Designated Contracting States:  
**DE ES FR GB IT NL PT**

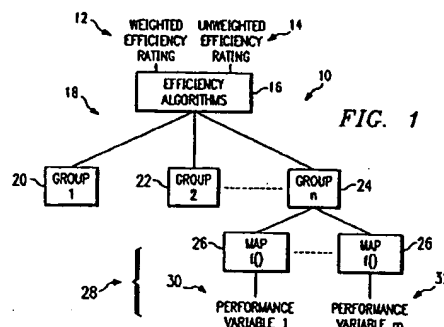
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(64) Method and system for monitoring and/or controlling the performance of an organization.

(57) A method and system generate performance data relating to the efficiency of an organization and include the steps of and instructions for describing a plurality of performance variables associated with the organization. The performance variables describe measurable properties of the organization. The invention further maps each of the performance variables to a normalized performance variable mapping that has a neutral value and at least one inflection point of the performance variable within a normalized range of values. Each inflection point describes effects of the normalized performance variable in changing from a positive influence to a negative influence on the organization's efficiency. Then the invention assigns a weighting factor to each of the normalized performance variables to produce a plurality of weighted normalized performance variables. The method and system calculate the efficiency of the organization as a function of the plurality of weighted normalized performance variables. The method and system further include the use and maintenance of instruction tables for identifying interactions among the various performance variables.



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The invention relates to an automated process control method and system. In particular, the invention relates to a method and system for monitoring and/or controlling the performance of an organization with regard to the complex processes to be found in such an organization.

Virtually every organization may be described as a system that converts one or more resources into one or more products or services. For example, a manufacturing organization converts raw materials, the fixed or capital resources of a manufacturing plant, and labor into a physical product. Likewise, a service organization transforms raw materials, labor, office space, and any necessary equipment into services for its customers. Income and expenses are inherent features of both types of organizations. The efficiency of an organization in using these resources is a direct measure of organizational performance.

Typically, organizations use a wide variety of methods to measure their performance. A manufacturing organization, for instance, may consider data such as labor hours per unit of production, total or incremental costs per unit of production, income per unit of production, or defects per unit of production in measuring its performance in these types of organizations. By considering the service provided by a service organization to be its "product," it is feasible to use similar measures to gauge organizational performance in these types of organizations. These measures of performance tend to focus on one or more particular aspects of an organization.

In order to measure and improve overall performance, managers frequently analyze these measurements that together can form voluminous and complex data sets. In most cases, however, the manager must ultimately rely heavily on his or her experience and skill to balance and identify the various aspects of organizational performance. Once this is done, the manager determines which aspects of the organization require improvement and tries to prioritize efforts to achieve these improvements. After modifying the organization as suggested by the foregoing analysis, the manager must compile new data that relate to the performance of the modified organization and compare that data with the previous data to compare how beneficial the modifications may have been. The process of collecting and analyzing data may take considerable time. During this time, however, ineffective or counter-productive operations may remain in place. These time delays and managerial inefficiencies often work to the detriment of the organization's overall efficiency.

Often, the key to the efficient operation of an organization is related, at least in part, to the efficient utilization of technical resources of that organization. This can apply equally to service as well as manufacturing organizations. Consider, for example, a call traffic processing centre, such as an airline reservation centre. Such a call centre is usually operated in one room with telephone operators (agents) numbering from twenty to one thousand. A call centre is created to handle a large volume of generic calls by using an Automatic Call Distributor System (switch). As a call comes in to the call centre, the switch literally "switches" the call to the next available agent for handling. Obviously, the success of a call centre depends upon customer satisfaction, which is related to many variables including the length of time before the phone is answered, the length of time on hold, and so on. Managing the operation of such a call centre requires the collection of large amounts of data which, traditionally, have had to be analyzed manually in order to reach any meaningful conclusions on possible improvements to the overall operation of the organization. The manual analysis of such data inevitably means that delays occur during which time organizational and technical changes cannot be made in real time to take account, for example, of fluctuating demands on the overall organization.

Consequently, there is a need to be able automatically to perform active and real-time assessment of an organization's performance on the basis of the performance-related operating parameters in a manner which mitigates the problems of off-line management performance assessment as described above.

Various aspects of the invention are set out in the appended claims 1, 2, 11 and 12, respectively. Preferred aspects of the invention are set out in the dependent claims.

Embodiments of the invention enable a quantitative and realistic assessment of an organization's efficiency.

Embodiments of the invention can also enable an analysis of an organization's performance on a variety of levels including between groups of an organization as well as between time periods of an organization's operation.

Embodiments of the invention can also enable the effect that different organizational performance parameters have on one another and can enable information to be generated as to which variables most strongly affect the organization's performance.

In embodiments of the invention, these advantages can be achieved with a minimum of programming and data entry.

The present invention, accordingly, provides a method and system for monitoring and controlling the performance of an organization and the efficient use of its technical resources that overcomes or reduces disadvantages and limitations associated with prior approaches to organizational performance and efficiency monitoring and control.

One aspect of the invention is a method for automatically generating performance data relating to the efficiency of an organization that includes the steps of first describing numerous performance variables associated with the organization. The performance variables relate to measurable properties of the organization. The next step is to map each of the performance variables to a normalized performance variable having a neutral value and at least one inflection point within a normalized range of values. The inflection point describes the changing effects of the normalized performance variable on the organization's efficiency as the variable changes from a minimum value to a maximum value. Next, the method includes the step of assigning a weighting factor to each of the normalized performance variables to produce weighted normalized performance variables. The weighting factor relates to the importance or perceived importance of each of the normalized performance variables to the efficiency of the organization. The method further includes the step of calculating an efficiency ratio that describes the efficiency of the organization as a function of the weighted normalized performance variables.

According to another aspect of the invention, there is provided a system for monitoring and controlling the efficiency of an organization that includes means for selecting numerous variables that relate to the organization's performance, such as a programmed computational device or computer whereby the computer can characterize the efficiency of the organization. A constant time interval can be selected during which to accumulate points that serve as values for performance variables. At least one interaction table can be provided for relating the performance variables to one another. Performance variable data for the most recent time interval is collected and then a defined efficiency rating is calculated for the most recent time interval using the collected data.

The system may also include a function for determining a trend of the organization's efficiency by comparing the calculated efficiency rating with a previously calculated efficiency rating. This previously calculated efficiency rating may be, for example, an efficiency rating that was calculated using data from a group consisting of ideal performance variable values, average performance variable values and changing or variable performance variable values for a previous time interval. Furthermore, the system preferably determines the relative impact of each performance variable on the organization's efficiency rating for the most recent time interval. The system allows repeating these functions often so that an assessment of interactions among the performance variables as well as the accuracy of the calculated efficiency rating can be improved.

A technical advantage of the present invention is that it provides current information that can be used to actively manipulate performance factors within an organization. This facilitates the ability to enhance the organization's efficiency. This is accomplished by the use of an empirically valid method to account for the various factors that affect the overall performance of the organization. The method and system provide an efficiency rating of the organization's performance and indicate which factors have the greatest impact on the efficiency rating. Advantageously, the method allows the measurement of the performance of the organization to be made frequently and to enable those factors having the greatest impact on the efficiency rating to be modified in a timely manner. As a result, a more rapid and more effective improvement of the organization's performance can be achieved.

Advantageously users are able to make direct inputs into the process using their knowledge and experience for determining the efficiency rating and, thereby, immediately alter the method's outcome. Advantageously, the ability to make such inputs allows the definition of "good performance" an organization to be changed. The method provides information that suggests how to modify the organization to achieve the newly-defined "good performance." This may be accomplished on a variety of levels including, for example, comparing efficiency ratings and performance variables of similar organizations, different groups within an organization, as well as various time periods for a single organization.

Yet another technical advantage of the present invention is that it is suitable for a variety of types of technical resources of an organization as well as a variety of different types of organizations. The method and system detect changes in an organization's monitored performance variables. Given the monitored performance variables, an embodiment of the invention can produce a rating of the efficiency of the organization in terms of a single number that describes the organization's performance. An embodiment of the invention dynamically track the interactions of an organization and detect deviations from the typical or anticipated interactions. This permits users to contrast their understanding or theory of how the organization operates with the actual interactions that occur within the organization.

Given a set of monitored performance variables, an embodiment of the invention can produce interaction tables to relate variables to one another. An embodiment of the invention can automatically populate the interaction tables based on trends detected during system operation thereby providing a technical solution to the problem of managing the information to be processed in an automatic manner. The interaction tables identify potential cause and effect relationships between monitored performance variables. This provides an indication of what causes a parameter to change as a function of input data and can significantly aid in improving

the efficiency of the organization.

An embodiment of the invention is also able to react automatically to external changes that affect the organization. These external effects may be, for example, a cyclical or repetitive event such as the particular day of the week or a single or isolated event such as an election or severe weather conditions. An embodiment of the invention takes these external changes automatically into account and provides an even more accurate picture of the organization's general efficiency, thus providing a technical solution to the problems of adaptive data management for real time applications.

Embodiments of the invention will be described hereinafter, by way of example only the accompanying drawings, in which:

FIGURE 1 provides a functional diagram of the efficiency rating process of the present embodiment;

FIGURE 2 provides a functional diagram of the interaction table formulation and maintenance process of the present embodiment;

FIGURE 3 provides a conceptual flow diagram of the output of a change detection function of the present embodiment;

FIGURE 4 provides an interval representation of a performance variable according to the present embodiment;

FIGURE 5 conceptually illustrates the ideal goal mapping function of the present embodiment;

FIGURE 6 conceptually illustrates the ideal cost mapping function of the present embodiment;

FIGURE 7 conceptually illustrates the ideal peak mapping function of the present embodiment;

FIGURE 8 illustrates an interaction table according to the present embodiment;

FIGURES 9 and 10 illustrate impulse functions that may be used with the present embodiment;

FIGURES 11 and 12 illustrate impulse response functions for use with the present embodiment;

FIGURE 13 illustrates a convolution of FIGURE 10 and FIGURE 12 for modelling an aspect of the present embodiment; and

FIGURE 14 is a schematic block diagram illustrating a second embodiment of the invention.

The present embodiment of the present invention is best understood by referring to the FIGURES wherein like numerals are used for like and corresponding parts of the various drawings.

The present embodiment of the present invention provides a method and system for monitoring and controlling the performance of an organization. The method includes the use of steps that give efficiency ratings for the organization as a whole, as well as ratings at the group or functional level. This performance monitoring process is augmented by a limited representation of the organization. The framework providing this representation is a series of tables that show how performance variables interact. The method makes use of deviations from an expected operation to help identify an area that needs better control. The system is preferably implemented as a suitably programmed computer system, although it will be understood that purpose built hardware could be provided for implementing at least some of the functions of the method to be described hereinafter. The computer system is connected to technical resources of the organization or otherwise arranged to enable the capture of performance related variables and parameters relating to the operation of the organization.

The method and system are comfortably applicable to a variety of computing systems. The present embodiment, for example, includes a process that first provides a single number describing an organization's performance. This single number provides a focus on how the organization is currently operating. The single number is called herein an "efficiency rating" and might be thought of as an impression or overall view of the organization's efficiency.

To illustrate the present embodiment of the present invention, FIGURE 1 shows the efficiency rating process flow diagram 10 for generating a weighted efficiency rating 12 and an unweighted efficiency rating 14. Weighted efficiency rating 12 and unweighted efficiency rating 14 are the outputs of efficiency algorithms 16 as applied at group level 18 to all of the groups within an organization. In particular, reference numeral 20 designates group 1, reference numeral 22 designates group 2, and by abbreviated representation reference numeral 24 represents groups through group n. Each of the groups 18 within an organization makes use of mapping functions 26 to map the values of their associated performance variables 28 to an interpretation formed by well-defined functions. In FIGURE 1, performance variable 1 is designated by reference numeral 30 and performance variable m relates to reference numeral 32.

The present embodiment provides details at group level 18 to help pinpoint trouble areas. A group, such as group 1 at reference numeral 20, might represent a branch of the organization like sales or development, or perhaps depict business indicators like revenue and expenditures. Groups are internal to the system and are places where performance variables 28 congregate. Associated with each group is a weighting factor that determines the relative importance of group performance variables 28 to the efficiency of the organization. Details at group level 18 are expressed in terms of how a group contributes to its parent organization's overall rating. This contribution may be positive, negative, or inconsequential. A group rating is available as its numerical

effect on the efficiency rating of the organization and as a signed percentage of the group's maximum possible contribution or detriment.

Performance variables 28 link the real world with the system of the present embodiment by providing data from measurable areas of the organization. The data could be input manually, although advantageously at least some of the data is captured automatically, for example by monitoring computer operations within the organization. Setup of the system, therefore, includes appropriately choosing performance variables 28 and describing their characteristics. One characteristic of performance variables is to which group the performance variables belong. Thus, where the variables are stored as records or words in the memory of a computer system, they are preferably associated with characteristic attributes. The efficiency rating at group level 18 depends on the performance variable according to the variable's relative weighting within the group and its current place within its operating range.

A set of ratings may be enough for detecting a changing trend in an organization. The ratings alone, however, are not sufficient to determine exactly what has changed. The ratings indicate how the changes have affected the organization and its groups. They do not directly pinpoint what has changed. Thus, not only does the method and system of the present embodiment provide quantitative information about the organization, the present embodiment also dynamically tracks the interactions of an organization and detects deviations from the typical interactions. This process occurs through the use of interaction tables which are set up and maintained automatically by the system.

To conceptually illustrate the process of creating and maintaining interaction tables, FIGURE 2 shows a flow diagram of interaction table process 35. Beginning with performance variable 1 at reference numeral 30, not only does mapping function 26 normalize the value for performance variable 1 for use by group function 24, but also change function 34 determines the existence of a change in performance variable 1 from time to time and outputs a change indication to interaction tables maintenance function 36. This occurs for all performance variables 28 including performance variable m at reference numeral 32. That is, for example, performance variable m is an input to change function 38. Change function 38 provides an input to interaction tables maintenance function 36. The result of interaction tables maintenance function 36 is an updated interaction table 40 that defines relationships among the performance variables 1 through m. As FIGURE 2 further illustrates, interaction table 40 also permits the use of tools 42, including for example, query 44 and miscellaneous other tools as block 46 connotes.

Interaction table process 35 of FIGURE 2 recognizes that it is aware of the intended principles (the intent or theory) of an organization. Interaction maintenance process 36, however, provides a contrast to this by tracking the actual interactions of the organization. The various interactions are detected by the system and stored in multiple interaction tables such as interaction table 40. The result is an authentic model that changes with the organization. This information permits management to contrast the theoretical and factual aspects of an organization's performance.

Interaction table process 35 may be used independently of efficiency rating process 10. Performance variables 28 are used as low level input to interaction table process 35 when interaction tables 40 are tied to the efficiency rating process 10. In operation, interaction table process 35 first determines what, if any, performance variable values have changed. FIGURE 3 illustrates the operation of a change function such as change function 34 of FIGURE 2. Just as performance variable 28 is mapped before being considered in efficiency rating process 10, it is also preprocessed before being considered in interaction tables process 35. This preprocessing is arranged during the definition of performance variables 28. The performance variable's definition references a function that defines change. This reference includes parameters necessary to satisfy change function 34.

The result of activating change function 34 is a value that specifies what has happened to the performance variable 28. The performance variable 28 has either gone up, dropped, or it has stayed the same. Change function 34 only reports significant changes between the variable's current measurement and its standard value. Change function 34 allows the user to specify how much of an upward rise or downward fall is significant to the organization. Change functions 34 that the present embodiment includes are a relative change and a percent change function. The percent change function uses a percentage of the reference value to compute the lower bound and another percentage of the reference value to compute the upper bound of an interval. The relative change function uses absolute numbers to compute the bounds of this interval. For example, suppose that performance variable 30 changes beyond a specified interval. Change function 34 will output either a +1 to indicate a rise in the performance variable 28 value beyond the applicable interval (as reference numeral 48 designates), a zero value in the event that no change in the variable occurs outside the specified interval (as reference numeral 50 identifies), or a -1 in the event of a fall in performance variable 30's value outside the interval (as reference numeral 52 indicates).

Performance variables 28 are mapped by the rating system into the interval [-1.0, +1.0]. FIGURE 4 illus-

G = the total number of groups in an organizations configuration  
 UER 14 is a number in the interval [0, +1.0]. If UER 14 has a value of 0.5 or 50%, this means that everything is operating at an ideal level, or more realistically, that the positive influences in the organization balance equally with the negative influences in the organization.

The contribution to UER 14 for a particular group  $f$  is:

$$U = \frac{R_f}{2G} \quad (3)$$

This is a number in the interval [-1/2G, +1/2G]. UER 14 having a value of 0.5 is the base line, so UER can also be expressed as:

$$UER = 0.5 + U_1 + U_2 + \dots + U_G \quad (4)$$

Unweighted efficiency rating 14 gives the user a notion of how the group's weights are biasing the organization's weighted efficiency rating 12. UER is only intended as a cross check for the user. Applying weights to each group gives the weighted efficiency rating (ER) 12 as follows:

$$ER = \frac{\sum_{f=1}^G W_f + \sum_{f=1}^G W_f R_f}{2 \sum_{g=1}^G W_g} = 0.5 + \frac{\sum_{f=1}^G W_f R_f}{2 \sum_{g=1}^G W_g} \quad (5)$$

As with UER 14, ER 12 is a number in the interval [0, +1.0]. Group  $f$ 's contribution to ER 12 is calculated as follows:

$$E = \frac{W_f R_f}{2 \sum_{g=1}^G W_g} \quad (6)$$

Once again, ER 12 having a value of 0.5 is the efficiency rating base line, so:

$$ER = 0.5 + E_1 + E_2 + \dots + E_G \quad (7)$$

Note that weighted ER 12 is intended to focus management's attention. Similar ratings are produced for each group at group level 18 in the organization. These also serve to focus management's attention. The ratings themselves have not suggested any specific trouble area beyond the group level.

As already explained in general, the present embodiment not only provides quantitative information about the organization, it also furnishes interaction information among performance variables 28. FIGURE 8, therefore, illustrates conceptually interaction table 40 what might result in the profit performance variable in the event of a decrease in a cost of goods sold. For example, interaction table 40 includes along its side a performance variable for the cost of goods sold at reference numeral 102. In this example, cost of goods sold performance variable 102 operates as an independent performance variable. The reaction to a decrease in the cost of goods sold by the profit performance variable 104 is represented by the "+" in cell 106. This represents the intersection between the performance dependent profit variable 104 and cost of goods independent performance variable 102. This may be taken as meaning that for a negative change or fall in cost of goods sold performance variable 102, a positive effect occurs on profit performance variable 104 as indicated by the "+" in cell 106.

Algorithms that use and maintain interaction tables 40 treat performance variables 28 as co-dependent variables. Interaction table 40 is two dimensional in representing how a given change in the row variable affects the column variable. Each performance variable 28 is assigned a selector value that is used for row and column addressing. The row variable, for example, cost of goods performance variable 102, may be considered the independent or acting variable and the column, for example, profits performance variable 104, variable may be considered the dependent or reacting variable. Given an acting variable and its classification, the method and system of the present embodiment can query interaction table 40 to determine how an acting variable change affects the remaining variables.

Performance variable classifications are produced by change functions, and one interaction table can exist per classification. As a result, for a given view of an organization, up to three interaction tables 40 are possible. In the present embodiment, each interaction table represents a square matrix. So if  $n$  performance variables

28 are involved, then without any attempt to minimize data storage requirements, each interaction table 40 will have  $n^2$  cells.

Interaction table 40 entries store values that describe the observed relationships between the acting (row) variable and the reacting (column) variable. To determine how interaction table 40 should depict the relationship between two variables, consider the realistic combinations of two changing numerics. Given either a rise, a stable level, or a fall in one variable, its effect on another variable can be described using the symbols of Table 1.

TABLE 1	
Symbol	Comments
+	reacting variable rises
-	reacting variable falls
N	reacting variable stays the same
u	reacting variable will not rise (it either falls or stays the same)
d	reacting variable will not fall (it either rises or stays the same)
n	reacting variable will not stay the same (it either rises or falls)
*	no clear trend

Referring to FIGURE 2, interaction table maintenance module 36 produces one of the above entries for each cell in interaction table 40. The entries are the result of examining statistics that are collected by interaction table maintenance modules 36. Interaction table maintenance module 36 calculates its results on the observed interaction of the variables over several samples. Consequently, interaction table 40 entries represent how performance variables 28 are actually interacting rather than the theory of how they should interact. In contrast, if the user were to manually fill in interaction table 40, then the table would represent the theory of how variables should interact. Interaction table maintenance module 36 assures that the present method and system change as the organization changes, while remaining stable enough to detect short term deviations. The present method and system use multiple interaction tables such as interaction table 40 to provide up-to-date and objective information about an organization's interactions.

The present embodiment uses interaction tables 40 to store a model of the current interactions of an organization's key indicators. When used with the efficiency rating as part of the present embodiment, these key indicators are the performance variables 28 that the user has defined. After producing an efficiency rating, the system proceeds to match current interactions amongst performance variables 28 against the stored model. The present embodiment presents a ranked list of performance variables 28 that deviate from the organization's model. This list provides specific information to management on areas that have suddenly changed.

A deviation from the model is a mismatch between the current relationship and the stored relationship between two performance variables 28. If a model says, for example, that a rise in performance variable A is correlated to a rise in performance variable B and the current sampling indicates otherwise, then a deviation would be noted. Both the acting and reacting variables are implicated by a deviation, so at least two ways exist to count deviations from the model. The first approach is to count the deviation against the acting variable. Accumulating deviations in this manner allows detection of weakening or changing relations between the acting variable and certain reacting variables. A ranked list of acting variables is really a list of variables whose relations, if the current situation persists, are subject to change in the model. Another method counts deviations against the reacting variable. Accumulations from this technique imply that something external to the model has affected the reacting variable. The invention allows either approach to be used without departing from the spirit or scope, but the latter gives more valuable input for keeping an organization on track, so the present system prefers to issue a ranked list of reacting variables to help the user determine why his efficiency rating has changed.

The following discussion more particularly describes operation of the interaction table query tool 44, as applied to interaction table 40 of FIGURE 8. For example, suppose that cost of goods performance variable 102 is the acting variable of interest and one wishes to know its effect on the organization being modelled. A first step of module 44 is to select the row associated with cost of goods performance variable 102 in interaction table 40. Then each table entry in that row is scanned for significant relations. Eventually, the reacting variable

profit is implicated because, in this example, cost of goods performance variable 102 falling ties to profits changing. The resulting cell entry indicates that, based upon past history, this will cause profit variable 104 to rise when cost of goods variable 102 falls.

The present embodiment also addresses the question of what happens when the system has not encountered the particulars being queried. This situation is easily detected by examining the statistics of the acting variable's row. If the system has never witnessed cost of goods falling, then the implicated row statistics will all be nil. Thus, interaction table 40 naturally supports a system that must know when it reaches its limits of experience.

In keeping with the above example, "What would cause profits to rise?" is a viable question. With this question profit performance variable 104 is a reacting variable, so its columns in the various interaction tables such as interaction table 40 are searched for the "+" symbol. During this kind of query, the system searches all interaction tables because a specific interaction table implies the acting variable's classification. Therefore, each interaction table is capable of storing the desired relation. If the system has never witnessed profits rising, then the implicated columns of the various interaction tables will have nil statistics for profits rising. The interaction tables may, however, have counts of events where profit has fallen or stayed the same.

An interesting characteristic of interaction table 40 is the ability to detect boundaries of the stored model. The user may define key indicators that, at least in theory, should have an effect on the organization, but perhaps for some reason the intended effects are not being realized. Modelling an organization by storing and tracking interactions allows the method and system of the present embodiment to detect boundary segments of the model, because variables that do not affect other variables will have zero or nil row statistics. Likewise, if the column statistics of a variable are nil, then the model has no knowledge of how to affect that variable.

At the start of the interaction table maintenance module 36 operation, each performance variable 28 in the system is classified using its change function 34 and a reference value. The classification of a performance variable 28 indicates whether the variable has risen, stayed the same, or has fallen. A reference value necessary for classifying the performance variable is selected based on a previous measurement, the day of week, an ideal value, or some other relevant criteria. If this is Monday and the reference values chosen are from one week ago, then interaction table 40 will be a model of how the organization typically interacts on Mondays.

One purpose of classifying each performance variable 28 is to accumulate statistics concerning how performance variables 28 tend to interact. One counter is maintained per classification for each performance variable combination. Each cell of an interaction table 40 is supported by three counters. For example, a system with  $n$  variables has  $n^2$  entries per interaction table 40, so without any attempt to minimize data storage requirements, there are  $3n^2$  discrete counters or statistics to store. If the system has received a new sample for its performance variables 28, then the pseudo-code for adding the samples to the interaction tables could be as shown below in Table 2:

35

TABLE 2	
40	<u>Using the current samples/classifications to be added to the system</u>
	<u>For each performance variable A</u>
	<u>    Select the interaction table corresponding to A's classification</u>
45	<u>    For each remaining variable R</u>
	<u>        Select interaction table entry [A,R]</u>
	<u>        Increment the statistic corresponding R's classification</u>
50	<u>    End for</u>
	<u>End for</u>

55

If a set of statistics are backed out of the present system when a new set of statistics are introduced, then a low pass filter has been implemented. The effect, as Table 3 shows, is a model that changes with the organization, but that is stable enough to aide in detecting short term deviations.

TABLE 3

Using the samples/classifications to be backed-out of the system.

For each performance variable A,

Select the interaction table corresponding to A's classification

For each remaining variable R,

Select interaction table entry (A,R)

Decrement the statistic corresponding R's classification

End for

End for

To convert cell 106 statistics to a relational symbol, it is necessary to take each of the three numbers, rank them, examine the ranking, then choose one of the seven relation symbols. The statistics give the number of times that a variable either rose, fell, or stayed the same in a specific situation or instance of a particular variable. Ranking these numbers requires that an interval of equivalence is established. If a variable, for example, rises 100 times, falls 99 times, and stays the same 2 times, then the rise and fall times are reasonably equivalent. There are many algorithms that the present embodiment could use to establish an equivalence interval. One example is to take the highest statistic and call any number within 10% of that statistic equivalent.

The ideal situation is for a clear choice to exist. In this case, the second and third place numbers are of no concern because the prevailing trend is immediately apparent. In the present embodiment, a tie for first is possible. This situation is resolved by considering the remaining statistic. The reacting variable will not react according to the remaining statistic, but it may follow either of the first place statistics.

TABLE 4

Ranking	Resulting Symbol	Comment
1,1,1	*	No clear trend
1,1,2	u,d, or n	Tie for first
1,2,3	+, -, or N	Clear trend
1,2,2	+, -, or N	Clear trend with a tie for second

The raw form of interaction tables 40 represent what has been observed. No guarantee exists, however, that the relations are consistent from one interaction table 40 to another. Post-processing algorithms examine the relations across interaction table 40 boundaries.

The present embodiment has the ability to respond to external events to help a manager understand how they affect the organization's efficiency rating and interaction amongst the performance variables. Thus, once the method and system has a set of satisfactory performance variables 28, it is possible to assess how an external event varies the organization's response. In deriving an efficiency rating, therefore, the process is to select several parameters that related to the performance of an organization as efficiency performance variables 28. The method and system measure these performance variables 28 for a period of time to derive efficiency ratings, which are functions that describe the values of those performance variables 28 at various instances of time. From the efficiency measurements, the present embodiment constructs interaction tables 40 that describe the expected change of one performance variable when another performance variable changes. Based on interaction table 40 answers the present embodiment permit manager queries such as how to improve a performance variable 28 or what if a performance variable 28 increases.

In the method and system, external events are the occurrence of some incident at some instance of time and that may happen repeatedly at some other instances of time. For example, an event can be a stock crash

where the stock crash is defined to be that the Dow Jones index drops more than 20% in one day. Other examples of parameters associated with external events may be Friday afternoon, a presidential election, rain, a full-moon, etc. An external event should be sufficiently re-occurring to derive a conclusive statement about the correlation of the event and the efficiency-rating. For example, if the stock index rarely drops more than 20% in one day, then the present system could change the threshold to 10% or even 5% so that the event happens more frequently.

The occurrence of an event may be modeled mathematically as an impulse function at that instance and, if the event happens many times, it may be modeled as a sequence of impulse functions. FIGURE 9, therefore, shows an example of impulse function at point 110. FIGURE 10 shows a sequence of impulse functions at points 112, 114 and 116. The impact of an event can be modeled automatically by an impulse response function which describes how strong the impact will be at various instances of time after the event happens. FIGURE 11 shows a sample impulse response function at curve 118, and FIGURE 12 shows another sample impulse response function at curve 120.

If an event happens many times, the impact of this event can be modeled by the convolution function of the sequence of impulses and the impulse response function at curve 122. FIGURE 13 at the curve 122 illustrates at curve 122 the convolution of FIGURE 10 and FIGURE 12. With the modelling approach of the present embodiment, events can be modeled as variables and the efficiency-rating and interaction tables comfortably handle both performance variables 28 as well as external events. FIGURE 13 shows how the impulse function of an event may be thought of as the measurement function of a performance variable 28. As far as the system of the present embodiment is concerned, an event may be considered as equivalent to a performance variable.

An important consideration in modelling external events is the search for the appropriate impulse response function of an event. The choice of the impulse response function of FIGURES 9 and 10 is crucial to the derivation of interaction table 40 because an improperly chosen impulse response function may result in an incorrect interaction table 40. The following discussion, therefore, addresses the issue on how to find the most correlated impulse response function for an event. An improperly chosen impulse response function usually results in missing an existing correlation, instead of showing a false correlation. This means a strong correlation indicates that the correlation indeed exists. A weak correlation, on the other hand, may simply indicate a bad choice of the impulse response function and, therefore, indicate the need for further investigation.

For the purposes of the present method and system, the main parameters of the impulse response function are the delay, duration, and the shape of the function. The delay describes how long it takes for an event to influence the efficiency-rating. The duration describes how long the impact lasts. The shape describes the relative strength of the impact. With an embodiment of the invention, many impulse response functions with varying delays, durations, and shapes can be examined to find out which one results in the strongest correlation. Then, the present embodiment selects that one strongest correlated function as the most appropriate impulse response function. An example search algorithm is to use the steepest-descent search when some correlation is detected and to use the random search when no correlation is discovered. There are many search algorithms that the present embodiment can use to solve this problem. If, on the other hand, no impulse response function shows a strong correlation, it is likely that this external event is unrelated with the efficiency-rating. If there exists an impulse response function that shows strong correlation, the external event can indeed change the efficiency-rating.

In summary, there is shown as one embodiment of the present invention a method and system for generating performance data relating to the efficiency of an organization that includes the necessary steps of and instructions for describing a plurality of performance variables associated with the organization. The performance variables associate with a measurable property of the organization. Mapping each of the plurality of performance variables to a normalized performance variable according to a neutral or ideal value and at least one inflection point of the performance variable within a normalized range of values is another function of the present invention. The inflection point generally describes effects of said normalized performance variable in changing from a positive influence to a negative influence on the organization's efficiency. The invention assigns a weighting factor to each of the normalized performance variables to produce a plurality of weighted normalized performance variables. The weighting factor relates to the importance of each of the normalized performance variables to the efficiency of the organization. The method and system calculate the efficiency of the organization as a function of the plurality of weighted normalized performance variables.

The present method and system also include the process of and instructions for constructing and maintaining interaction tables, as well as the ability to query interaction tables. Such queries could include queries such as "what in fact would happen if I changed the 'x' performance variable" or "what would cause a change of 'y' percent" in the 'z' performance variable?" Change functions are employed for constructing and maintaining interaction tables and to compare current measurements against the interaction tables. Therefore, a list of deviations can be produced by acting variables as well as by reacting variables. Furthermore, an embodiment

of the invention permits external events to be transformed into performance variables by using impulse and impulse response functions. These impulse and impulse response functions permit external events to be employed in efficiency rating calculations as well as in the formation of interaction tables.

Another embodiment of the present invention applies to a call traffic processing center, such as an airline reservation center. Figure 14 is a schematic overview of such a call centre in combination with a controller C for implementing the invention.

The call centre, which is typically operated in one room with telephone operators (agents) (A1 ... An) numbering from twenty to one thousand, is able to handle a large volume of generic calls by using an Automatic Call Distributor System (switch) S. As a call comes in to the call centre from a telephone line T, the switch S literally "switches" the call to the next available agent A for handling. The success of a call center depends upon customer satisfaction, which is related to many variables including the length of time before the phone is answered, the length of time on hold, and so on. To demonstrate the operation of the invention, the method will be applied to a limited number of operating parameters, or variables, although it will be appreciated that in practice many more variables may be involved.

Accordingly, a controller C is preferably implemented as a suitably programmed general purpose computer, although it will be appreciated from a description of the functions to be described below that at least some of those functions could be implemented by means of special purpose functional units. The controller C is connected to the switch S so as to be able to monitor selected operating parameters of the system and to process those data as described above. The controller can also be connected so as to provide control information to the switch for controlling the operation thereof.

The first step of the method comprises selecting the performance variables to be measured. Ideally, all of the organization's variables should be measured. However, if only the variables considered most important are included, the method will still provide valid results.

In addition to selecting the variables to be measured, default values may be assigned for those variables. If a variable is unavailable at any time the method is being performed, its default value may be used to allow the method to be continued. If the default values are carefully selected, their use will not cause significant errors in the method's results.

The following call traffic processing center variables will be used to demonstrate the invention:

handled calls (HC) - the number of calls answered by the center's agents;  
abandoned calls (AC) - the number of calls in which the caller hung up before being answered by and agent;

line talk time (LTT) - the time during which the agents were speaking with callers on the telephone lines;  
line abandon time (LAT) - the time callers who abandoned their calls were waiting on the telephone lines;  
line idle time (LIT) - the time during which the telephone lines were unoccupied;  
agent talk time (ATT) - the time during which agents were speaking with callers on the telephone lines;  
agent work time (AWT) - the time during which agents were completing caller transactions, but were not talking with callers; and  
agent idle time (AIT) - the time during which the agents were not available to perform their functions.

The variables are components of the following:

processed calls (PC) = HC + AC;  
line available time (LT) = LTT + LAT + LIT; and  
agent sign on time (AT) = ATT + AWT + AIT.

After the variables to be measured are selected, a fractional weight is assigned to each variable and each variable is characterized as either positive or negative. The fractional weights reflect the subjective relative importance of each variable, as seen by the manager or user of the method. The sum of the fractional weights is one. The positive or negative characterization of variable depends upon a subjective determination as to whether an increase in that variable is seen to affect the performance of the organization favorably or unfavorably.

By assigning fractional weights to the variables and characterizing the variables as positive or negative, one essentially defines "good performance" for the organization. Thus, if one changes the fractional weights or characterization of the variables, one changes the definition of "good performance."

For purposes of the example, abandoned calls and agent idle time are each assigned twice the weight of the other factors, indicating their subjective relative importance. As can be seen callers; and

agent idle time (AIT) - the time during which the agents were not available to perform their functions.

The variables are component of the following:

processed calls (PC) = HC + AC  
line available time (LT) = LTT + LAT + LIT; and  
agent sign on time (AT) = ATT + AWT + AIT.

After the variables to be measured are selected, a fractional weight is assigned to each variable and each variable is characterized as either positive or negative. The fractional weights reflect the subjective relative importance of each variable, as seen by the manager or user of the method. The sum of the fractional weights is one. The positive or negative characterization of variable depends upon a subjective determination as to whether an increase in that variable is seen to affect the performance of the organization favorably or unfavorably.

By assigning fractional weights to the variables and characterizing the variables as positive or negative, one essentially defines "good performance" for the organization. Thus, if one changes the fractional weights or characterization of the variables, one changes the definition of "good performance."

For purposes of the example, abandoned calls and agent idle time are each assigned twice the weight of the other factors, indicating their subjective relative importance. As can be seen in Table 3 below, the total of the variable weights is one. Abandoned calls, line abandon time, line idle time, and agent idle time are characterized as negative, because increases in those variables are seen to decrease the performance of the center.

The variables are then assigned to one of a plurality of groups. Each group contains either positive or negative variables. In addition, each group contains only variables which are components of a particular resource, source of income, or expense. In the example, line abandon time and line idle time are both negative factors and belong to the same resource, line available time; therefore, they are placed together in a group. Similarly, agent talk time and agent work time are positive components of agent sign on time and are placed together in a group. As can be seen in Table 3 below, there are three positive groups and three negative groups in the example.

Two tables reflecting the interaction of the variables are constructed. The first table contains entries showing the expected reaction of each of the variables when another variable is increased and all other variables remain constant. For example, when handled calls increases, what is the expected reaction of abandoned calls, assuming the other variables remain constant? As can be seen in Table 1, the answer is that abandoned calls are expected to decrease. The other table (Table 2) shows the reaction when a variable is decreased.

In the below tables, a "+" entry indicates an increase in the variable listed on the horizontal axis and a "-" entry indicates a decrease.

TABLE 5								
Increasing	Reacting Variable							
Variable	HC	AC	LTT	LAT	LIT	ATT	AWT	AIT
Handled calls		-	+	-	-	+	+	-
Abandoned calls	-		-	+	-	-	-	+
Line talk time	-	+		+	-	+	-	-
Line abandon time	-	+	-		-	-	-	+
Line idle time	-	-	-	-		-	-	+
Agent talk time	-	+	+	+	-		-	-
Agent work time	-	+	-	+	+	-		-
Agent idle time	-	+	-	+	+	+	-	

TABLE 6

TABLE 6								
Decreasing	Reacting Variable							
Variable	HC	AC	LTT	LAT	LIT	ATT	AWT	AIT
Handled calls		+	-	+	+	-	-	+
Abandoned calls	+		+	-	+	+	+	-
Line talk time	+	-		-	+	-	+	+
Line abandon time	+	-	+		+	+	+	-
Line idle time	+	+	+	+		+	+	-
Agent talk time	+	-	-	-	+		+	+
Agent work time	+	-	+	-	-	+		+
Agent idle time	+	-	+	-	-	-	+	

The above steps are preparatory. The steps which follow are repeated at regular intervals. The length of the interval will of course vary depending upon the type of organization. In the present embodiment, the steps which follow are accomplished hourly by a digital computer system which obtains data from the call center's switch.

Data comprising the quantity of each variable occurring during a fixed time is collected. Table 3 below shows the data for the example. Table 3 also shows the weights of each variable and the groups to which they are assigned.

TABLE 7

Variable	Weight	Measured Value	Group
Handled calls	.1	1000 calls	A
Abandoned calls	.2	50	B
Line talk time	.1	21600 sec.	C
Line abandon time	.1	1440	D
Line idle time	.1	5760	D
Agent talk time	.1	21600	E
Agent work time	.1	4320	E
Agent idle time	.2	2880	F

Next, a variable ratio for each variable is calculated using the following formula:

$$VR = V/T, \quad (8)$$

where:

VR = the variable ratio,

V = the variable, and

T = the sum of the variables which are components of the resource, source of income, or expense of which the variable is a component.

In the example, handled calls (1000 calls) is a component of processed calls (1050) calls. Therefore, the variable ratio for handled calls is  $1000/1050 = 0.95$ . The variable ratios for all variables are shown in Table 4.

A weighted variable ratio is then calculated using the following formula:

$$WVR = VR \times W \quad (9)$$

where:

WVR = the weighted variable ratio,

VR = the variable ratio, and

W = the fractional weight assigned to the variable.

Continuing the example, the weight assigned to handled calls is 0.1. Therefore, the weighted variable ratio for handled calls is  $0.95 \times 0.1 = 0.095$ . The weighted variable ratios for all the variables is shown in Table 4.

TABLE 8		
Variable	Ratio	Weighted ratio
Handled calls	0.95	0.095
Abandoned calls	0.05	0.010
Line talk time	0.75	0.075
Line abandon time	0.05	0.005
Line idle time	0.20	0.020
Agent talk time	0.75	0.075
Agent work time	0.15	0.015
Agent idle time	0.10	0.020

The efficiency rating is then calculated using the following formula:

$$ER = 10 \times (0.1 \times N + PWVR = NWVR) / (P + N) \quad (10)$$

where:

ER = the efficiency rating,

N = the number of negative variable groups,

P = the number of positive variable groups,

PWVR = the sum of the weighted variable ratios of positive variables, and

NWVR = the sum of the weighted variable ratios of negative variables.

As seen in Table 3, there are three positive variable groups in the example and three negative variable groups. Thus, the efficiency rating is

$$10[(0.1 \times 3 + (0.095 + 0.075 + 0.075 + 0.015) - (0.010 + 0.005 + 0.020 + 0.020)) / (3 + 3)] = (0.3 + 0.260 - 0.055) / 6 = 0.84. \quad (11)$$

The efficiency rating may be compared with several other efficiency ratings in order to determine the trend of the organization's performance. Examples include an ideal rating, an average rating, and a rating for a previous period. The ideal efficiency rating may be calculated using theoretically possible data (data in which all of the negative variables are zero), data which experience has shown to be achievable, or data based upon management's view regarding the optimum values for each variable. The average rating may be taken for the life of the organization, for the previous year, quarter, or month, or for the day of the week, season, etc. Similarly, the previous efficiency rating may be for the period immediately preceding the current period or for the corresponding period during the previous day, week, year, etc. So long as the same average and previous efficiency ratings are used consistently, the invention will yield valid results.

Returning to the example, assume that the ideal efficiency rating is 0.92, the average rating is 0.87, and the last period's rating is 0.83. Comparing the efficiency rating for the current period calculate above with the assumed efficiency ratings,

current vs. ideal: the current rating is  $0.84/0.92 = 0.91 = 91\%$  of the ideal rating;

current vs. average: the current rating is  $0.84/0.87 = 0.97 = 97\%$  of the average rating; and

current vs. previous period: the previous period rating is  $0.83/0.84 = 0.99 = 99\%$  of the current period rating. Note that the maximum value that may be achieved in this comparison is 100%, as the two ratings are inverted when the current rating is greater than the rating to which it is compared.

In addition to comparing the efficiency rating with other efficiency ratings, the variable ratios and weighted variable ratios may be compared with the corresponding ideal, average, and previous period ratios to determine the deviation of the current ratios from the foregoing ratios. In the example, assuming an ideal handled calls ratio, the deviation of the current ratio is  $(0.95/0.98) - 1 = -0.03 = 3\%$  less than the ideal ratio.

The above comparisons of the current values of variable ratios, weighted variable ratios, and efficiency rating with the ideal, average, and previous period values provide an overall view of the performance of the

organization and the trend of that performance.

Next, the current interaction between the variables is compared with the expected interaction of the variables shown in Tables 1 and 2 to determine the number of times each variable's current interaction with the other variables deviates from the expected interaction.

TABLE 9		
Variable	Measured Value	Average Value
Handled calls	1000 calls	1200 calls
Abandoned calls	50	70
Line talk time	21600 sec.	23700 sec.
Line abandon time	1440	1620
Line idle time	5760	3480
Agent talk time	21600	23700
Agent work time	4320	4970
Agent idle time	2880	130

Returning to the example and assuming the average variable values shown in Table 5 above, we see that measured handled calls decreased relative to average handled calls. Therefore, we enter the table which shows the actions of the other variables when one variable decreases, Table 2, and compare the expected reaction of each other variable (obtained by reading horizontally from "handled calls") with the actual reaction. That comparison is accomplished as follows:

If handled calls decrease, then

Expected Reaction	Observed Reaction	Deviation?
Abandoned calls increase	decrease	yes
Line talk time decreases	decrease	no
Line abandon time increases	decrease	yes
Line idle time increases	increase	no
Agent talk time decreases	decrease	no
Agent work time decreases	decrease	no
Agent idle time increases	increase	no

As can be seen, the observed reactions for abandoned calls and line abandon time deviated from that expected. Continuing the example, observed abandoned calls is an increase relative to average abandoned calls. Therefore, we perform the above procedure by entering Table 2 and reading horizontally from "abandoned calls" and make the comparison as follows:

if abandoned calls increase, then

Expected Reaction	Observed Reaction	Deviation?
Handled calls increase	decrease	yes
Line talk time increases	decrease	yes
Line abandon time decreases	decrease	no
Line idle time increases	increase	no
Agent talk time increases	decrease	yes
Agent work time increases	decrease	yes
Agent idle time decreases	increase	yes

Thus far, it can be seen that there is one deviation each for handled calls, abandoned calls, line talk time, line abandon time, agent talk time, agent work time, and agent idle time. The results from completing the comparisons are shown in Table 6 below.

Next, the percentage of impact on the efficiency rating of each variable is calculated using the following formula:

$$I = 100 \times D/DT, \quad (12)$$

where:

I = percentage impact of the variable on the efficiency rating,  
D = the number of interaction deviations for the variable, and  
DT = the total number of interaction deviations.

In the example, the percentage impact for handled calls is  $100 \times 5/(5 + 2 + 3 + 2 + 1 + 3 + 4 + 2) = 500/22 = 22.7\%$ . The results from calculating the percentage impact for all the variables is shown in Table 6 below.

A calculated impact for each variable is then calculated using the following formula:

$$CI = I \times W, \quad (13)$$

where:

CI = the calculated impact of the variable,  
I = the percentage of impact of the variable on the efficiency rating calculated above, and  
W = the fractional weight assigned to the variable above.

The calculated impact for handled calls in the example is  $22.7 \times 0.1 = 2.27$ . The results from calculating the calculated impacts of all the variables are shown in Table 6 below.

The weighted percentage of impact of each variable on the efficiency rating is then calculated using the following formula:

$$WI = 100 \times CI/TCI, \quad (14)$$

where:

WI = the weighted percentage of impact of the variable on the efficiency rating,  
CI = the calculated impact of the variable calculated above, and  
TCI = the sum of all of the calculated impacts of the variables calculated above.

The weighted percentage impact of handled calls in the example is  $2.27/(2.27 + 1.82 + 1.36 + 0.91 + 0.45 + 1.36 + 1.82 + 1.82) = 2.27/11.81 = 19.2\%$ . The results from calculating each variable's weighted percentage impact on the efficiency ratio are shown in Table 6 below.

TABLE 10

Variable	Deviations	% Impact	Calc. Impact	Wtd. % Impact
Handled calls	5	22.7%	2.27	19.2%
Abandoned calls	2	9.1	1.82	15.4
Line talk time	3	13.6	1.36	11.5
Line abandon time	2	9.1	0.91	7.7
Line abandon time	1	4.5	0.45	3.8
Agent talk time	3	13.6	1.36	11.5
Agent work time	4	18.2	1.82	15.4
Agent idle time	2	9.1	1.82	15.4

Both the percentage impact and the weighted percentage impact figures indicate that handled calls had the greatest impact on the efficiency rating of the call traffic processing system of the example. While the management of the processing system cannot affect the number of calls available to the system for processing, the percentage and weighted percentage impact figures indicate that a greater number of calls should have been handled during the period, given the number of calls that were available for processing. That conclusion is reinforced by the relatively high figure for the abandoned calls weighted percentage impact. Noting that the figures for agent talk time and agent work time leads to the conclusion that greater than average time was spent on the average transaction during the period in question. Therefore, the efficiency rating of the system may be increased by encouraging rating of the system may be increased by encouraging the agents to handle transactions more expeditiously.

The example illustrates that the invention allows an organization's managers, in this case call center supervisors, to use their expertise to interact and direct the call center's functionality and efficiency in an active rather than passive manner. The invention allows immediate measurement and correction of the call center's performance.

A report including the comparisons of the efficiency rating for the current period with the ideal, average, and previous period's rating and the variable's percentage and weighted percentage impacts on the efficiency rating is prepared for use by the organization's management. As indicated above, the efficiency rating provides an organization's management measure of organization's overall performance, the comparisons of ratings indicate the trend of the organization's performance, and the impact figures provide a means to systematically modify the organization to improve its performance.

Various aspects of embodiments of the invention are summarised in the following paragraphs.

An embodiment of the invention provides a method for monitoring and controlling the efficiency of an organization (e.g., a call traffic centre) comprising the steps of:

- a) selecting a plurality of variables relating to the performance of the organization which together characterize the efficiency of the organization;
- b) selecting a constant time interval during which variable data is accumulated;
- c) constructing at least one interaction table which contains an expected change in each variable when any other variable changes;
- d) collecting variable data for the most recent time interval;
- e) calculating a defined efficiency rating for the most recent time interval using the variable data collected in step d;
- f) determining the trend of the efficiency rating from step e with at least one other efficiency rating, said other efficiency rating having been calculated using data selected from the group consisting of ideal variable values, average variable values and variable values for a previous time interval;
- g) determining the recent impact of each variable on the efficiency rating for the most recent time interval;
- h) based on the results of steps f and g, modifying the organization to improve its efficiency; and
- i) repeating steps (d) through (h) for each succeeding interval.

Step (c) can include the steps of:

- c1) constructing a first interaction table containing an entry for each variable reflecting whether that variable is expected to increase or decrease when another variable increases and all other variables remain

constant; and

c2) constructing a second interaction table containing an entry for each variable reflecting whether that variable is expected to increase or decrease when another variable decreases and all other variables remain constant.

5 The method can comprise a further step of updating the interaction tables after the other steps of the method have been performed, said updating being based upon accumulated data related to the actual change of each of the variables in response to a change in each of the other variables.

Step (g) can include the steps of:

g1) determining the change in the value of each variable for the most recent time interval relative to an average value of the variable;

g2) comparing the results of step (g1) with the interaction tables to determine the number of instances in which the change in each variable deviates from that predicted by those tables; and

g3) determining the impact of each variable on the efficiency rating for the most recent time interval by summing the number of deviations for each variable determined in step (g2), the variable having the most impact being the variable with the greatest number of deviations.

Step (g) can comprise steps of:

g4) for each variable, calculating a percentage impact of the variable on the efficiency rating for the most recent time interval using the following formula:

$I = 100 \times D/TD$ , where

I = percentage impact of the variable on the efficiency rating for the most recent time interval,

D = the number of interaction deviations for the variable, and

TD = the sum of interaction deviations for all the variables;

g5) for each variable, calculating a calculated impact of the variable using the following formula:

$CI = I \times W$ , where

CI = the calculated impact of the variable,

I = the percentage of impact of the variable on the efficiency rating calculated in step (g4), and

W = the fractional weight assigned to the variable;

g6) for each variable, calculating a weighted percentage impact of the variable on the efficiency rating for the most recent time interval using the following formula:

$WI = 100 \times CI/TCI$ , where

WI = the weighted percentage of impact of the variable on the efficiency rating,

CI = the calculated impact of the variable calculated from step (g5), and

TCI = the sum of all of the calculated impacts of the variables.

35 The method can be applied to a organization which expends one or more resources to produce one or more products or services and in doing so earns income from one or more sources and incurs one or more expenses and wherein the defined efficiency rating is calculated by means of the following steps:

a) assigning a fractional weight to each variable according to the relative importance thereof, the sum of said weights being one;

40 b) characterizing each variable as positive or negative depending upon whether an increase in the variable affects the performance of the organization favorably or unfavorably, respectively;

c) assigning each of said variables to one of a plurality of variable groups, each variable group comprising either the positive or the negative variables that are components of one of said resources, sources of income or expenses;

45 d) calculating the number of positive variable groups, a positive variable group being one which contains one or more positive variables;

e) calculating the number of negative variable groups, a negative variable group being one which contains one or more negative variables;

f) calculating a variable ratio for each variable using the following formula:

$VR = V/T$ , where

VR = the variable ratio,

V = the variable, and

T = the sum of the variables which are components of the resource, source of income, or expense of which the variable is a component;

g) calculating a weighted variable ratio for each variable using the following formula:

55  $WVR = VR \times W$ , where

WVR = the weighted variable ratio,

VR = the variable ratio calculated in step (f), and

W = the fractional weight assigned to the variable in step (a); and

h) calculating the efficiency rating using the following formula:

$ER = 10 \times (0.1 \times N + PWVR - NWVR) / (P + N)$ , where

ER = the efficiency rating,

N = the number of negative variable groups calculated in step (e);

5 P = the number of positive variable groups calculated in step (d);

PWVR = the sum of the weighted variable ratios calculated in step (g) which correspond to variables assigned to a positive variable group in step (c), and

NWVR = the sum of the weighted variable ratios calculated in step (g) which correspond to variables assigned to a negative variable group in step (c).

10 The method can further comprise the step of producing a report showing the values of the variables for the most recent time interval, the comparison of the efficiency rating for the most recent time interval with at least one of the other efficiency ratings, and the relative impact of each of the variables on the efficiency rating for the most recent time interval.

15 The method can further comprise the step of selecting default values for the performance variables, the default value being substituted for the variable when the value of the variable is not available for the most recent time interval.

20 An embodiment of the invention can also provide a method of monitoring and controlling the efficiency of an organization which expends one or more resources to produce one or more products or services and in doing so earns income from one or more sources and incurs one or more expenses and wherein the defined efficiency rating is calculated by means of the following steps:

a) selecting a plurality of performance variables to be measured, each variable being a component of one of said resources, sources of income, or expenses;

b) selecting a constant time interval during which variable data is accumulated;

25 c) assigning a fractional weight to each variable according to the relative importance thereof, the sum of said weights being one;

d) characterizing each variable as positive or negative depending upon whether an increase in the variable affects the performance of the organization favorably or unfavorably, respectively;

30 e) assigning each of said variables to one of a plurality of variable groups, each variable group comprising either the positive or the negative variables that are components of one of said resources, sources of income or expenses;

f) calculating the number of positive variable groups, a positive variable group being one which contains one or more positive variables;

35 g) calculating the number of negative variable groups, a negative variable group being one which contains one or more negative variables;

h) constructing a first table and a second table, which tables reflect an expected interaction of the variables, the first table containing an entry for each variable reflecting whether that variable is expected to increase or decrease when another variable increases and all other variables remain constant, and the second table containing an entry for each variable reflecting whether that variable is expected to increase or decrease when another variable decreases and all other variables remain constant;

40 i) collecting variable data for the most recent time interval;

j) calculating a variable ratio for each variable using the following formula:

$VR = V/T$ , where

VR = the variable ratio for the most recent time interval,

V = the variable from step (i), and

45 T = the sum of the variables from step (i) which are components of the resource, source of income, or expense of which the variable is a component;

k) calculating a weighted variable ratio for each variable using the following formula:

$WVR = VR \times W$ , where

WV = the weighted variable,

50 VR = the variable ratio calculated in step (j), and

W = the fractional weight assigned to the variable in step (c);

l) calculating an efficiency rating for the most recent time interval using the following formula:

$ER = 10 \times (0.1 \times N + PWVR - NWVR) / (P + N)$ , where

ER = the efficiency rating,

55 N = the number of negative variable groups calculated in step (g);

P = the number of positive variable groups calculated in step (f);

PWVR = the sum of the weighted variable ratios calculated in step (k) which correspond to variables assigned to a positive variable group in step (e), and

- NWVR = the sum of the weighted variable ratios calculated in step (k) which correspond to variables assigned to a negative variable group in step (e);
- m) comparing the efficiency rating for the most recent time interval from step (1) with an ideal efficiency rating, an average efficiency rating and the efficiency rating for a previous time interval;
- 5 n) comparing the value of each variable for the most recent time interval with an average value of that variable;
- o) using the results of step (n), determining the interaction between each variable and each other variable for the most recent time interval;
- p) using the results of step (o) and the tables constructed in step (h), determining each instance when the interaction of a variable with any other variable deviates from the expected interaction of the two variables;
- 10 q) for each variable, summing the number of deviations determined in step (p);
- r) for each variable, calculating a percentage impact of the variable on the efficiency rating for the most recent time interval using the following formula:
- $I = 100 \times D / TD$ , where
- 15 I = the percentage impact of the variable on the efficiency rating,
- D = the number of interaction deviations for the variable from step (q), and
- TD = the sum of the interaction deviations for all the variables;
- s) for each variable, calculating a calculated impact of the variable using the following formula:
- $CI = I \times W$ , where
- 20 CI = the calculated impact of the variable,
- I = the percentage of impact of the variable on the efficiency rating calculated in step (r), and
- W = the fractional weight assigned to the variable in step (c);
- t) for each variable, calculating a weighted percentage impact of the variable on the efficiency rating for the most recent time interval using the following formula:
- 25  $WI = 100 \times CI / TCI$ , where
- WI = the weighted percentage of impact of the variable on the efficiency rating,
- CI = the calculated impact of the variable calculated from step (s), and
- TCI = the sum of all of the calculated impacts of the variables from step (s);
- u) producing a report showing the values of the variables for the most recent time interval and the results of steps (l), (m), (r), and t;
- 30 v) based on the results of steps (l), (m), (r), and (t), modifying the organization to increase the efficiency of the organization;
- w) repeating steps (l) through (v) for each succeeding time interval.
- In other words, an embodiment of the invention also provide a method for monitoring and/or controlling
- 35 the efficiency of an organization comprising steps of:
- defining a plurality of performance variables associated with the organization, said performance variables being further associated with a measurable property of the organization;
- mapping each of said plurality of performance variables to a normalized performance variable having a neutral value and at least one inflection point within a normalized range of values, said inflection point describing varying effects of said normalized performance variable on the organization's efficiency;
- 40 assigning a weighting factor to each of said normalized performance variables to produce a plurality of weighted normalized performance variables, said weighting factor relating to the importance of each of said normalized performance variables to the efficiency of the organization; and
- determining the efficiency of the organization as a function of said plurality of weighted normalized performance variables.
- 45 The method preferably comprises a step of mapping a variable within a performance range having at least one good value and at least one bad value.
- The method preferably also comprises a step of normalizing said plurality of performance variables for comparing uncommon raw data values among one another.
- 50 The method preferably also comprises a step of setting said weighting to a value for providing an unweighted group weighting.
- The method preferably also comprises a step of calculating the efficiency of one or more or all of a plurality of organizational groups within the organization.
- The method preferably also comprises a step of calculating the efficiency of an individual portion of an organizational group within an organization.
- 65 The method preferably also comprises a step of transforming at least one external event into a performance variable for determining the effect on the organizations efficiency of a change and the external variable.
- The method preferably also comprises steps of:

defining a plurality of performance variables associated with a group within the organization, said performance variables being further associated with a measurable property of the organization;

mapping each of said plurality of performance variables to a normalized performance variable according to a neutral value and at least one inflection point of said performance variable within a normalized range of values, said inflection point describing varying effects of said normalized performance variable on the organization's efficiency;

assigning a weighting factor to each of said normalized performance variables to produce a plurality of weighted normalized performance variables, said weighting factor relating to the importance of each of said normalized performance variables to the efficiency of the organization;

determining the interactions among said weighted normalized performance variables;

recording said interaction between said weighted normalized performance variables in an interaction table, said interaction table comprising a plurality of values, each of said values for associating said weighted normalized performance variables among one another.

Said interaction recording step preferably comprises a step of recording in a first interaction table an entry for each performance variable that reflects whether the performance variable is expected to increase or decrease when another variable increases and all other performance variables remain constant.

The method preferably further comprising a step of describing significant changes in a performance variable through a change function.

The method preferably comprises a step of automatically recording said interactions between the performance variables.

The method preferably comprises a step of uniquely defining the format and content of the interaction tables.

The method preferably comprises a step of automatically establishing the format and content of the interaction tables.

The interaction recording step preferably further comprises a step of storing actually measured performance variables for indicating the actual performance of an organization.

The method preferably further comprises a step of querying said interaction tables to determine at least one factor that would cause a predetermined performance variable to change.

The method preferably further comprises a step of querying said interaction table to determine the effect on the organization of a change in a predetermined performance variable.

The method preferably further comprises a step of generating a list of possibly changing interactions as determined by a plurality of deviations from the interaction tables against a predetermined acting variable.

The method preferably further comprises a step of producing a list of variables that were possibly influenced by external forces as determined by deviations from the interaction tables against the reacting variable.

An embodiment of the invention also provides a system for monitoring and/or controlling the efficiency of an organization comprising:

means for determining a plurality of performance variables relating to the performance of the organization which together characterize the efficiency of the organization;

means for determining a plurality of time intervals during which to accumulate performance variable data;

means for constructing at least one interaction table that contains an expected change in each performance variable when at least one other performance variable changes;

means for collecting performance variable data for a most recent time interval;

means for calculating a most recent efficiency rating said the most recent time interval using said performance variable data;

means for determining the relative impact of each performance variable on the efficiency rating for said most recent time interval; and

means for modifying selected ones of said performance variables to increase the value of said most recent time interval.

An embodiment of the invention can also provide a system for monitoring and/or controlling the efficiency of an organization, comprising:

a plurality of performance variables for defining measurable properties associated with the organization;

mapping means defining a set of mappings for mapping each of said plurality of performance variables to a normalized performance variable according to a neutral value and at least one inflection point of said performance variable within a normalized range of values, said inflection point describing varying effects of said normalized performance variable;

weighting means defining a plurality of weighting factors for assigning to each of said normalized per-

formance variables for generating a weighted normalized performance variable, said weighting factors relating to a predicted importance of each of said normalized performance variables to the efficiency of the organization; and

5 efficiency calculating means for calculating the efficiency of the organization as a function of said weighted normalized performance variables.

The system preferably comprises means for mapping a variable within a performance range having at least one good value and at least one bad value.

The system preferably comprises means for normalizing said plurality of performance variables for comparing uncommon raw data values among one another.

10 The system preferably provides at least one weighting factor for setting said weighting to a value that provides an unweighted group weighting.

The system preferably comprises means for calculating the efficiency of one or more or all of a plurality of groups within an organization.

15 The system preferably comprises means for calculating the efficiency of an individual portion of a group within an organization.

The system preferably comprising means for transforming at least one external event into a performance variable for determining the effect on the organizations efficiency of a change and the external variable.

20 The system preferably comprises means whereby an inflection point describes effects of a normalized performance variable in changing from a positive influence to a negative influence on the organization's efficiency; and wherein

an interaction table is provided for recording said interaction between said weighted normalized performance variables, said interaction table comprising a value for associating said weighted normalized performance variables among one another.

25 The interaction table preferably comprises an entry for each performance variable that reflects whether the performance variable is expected to increase or decrease when another variable increases and all other performance variables remain constant.

The system preferably comprises means for describing significant changes in a performance variable through a change function.

30 The system preferably comprises means for automatically recording said interactions between the performance variables.

The system preferably comprises means for uniquely describing the format and content of said interaction table.

The system preferably comprises means for automatically establishing the format and content of the interaction tables.

35 The interaction table preferably stores actually measured performance variables for indicating the actual performance of an organization.

The system preferably comprises means for querying said interaction tables to determine at least one factor that would cause a predetermined performance variable to change.

40 The system preferably comprises means for querying said interaction table to determine the effect on the organization of a change in a predetermined performance variable.

The system preferably comprises means for generating a list of possibly changing interactions as determined by a plurality of deviations in a reacting variable of said interaction table from an expected reaction to a predetermined acting variable.

45 The system preferably comprises the step of producing a list of variables that were possibly influenced by external forces as determined by deviations from the interaction tables against the reacting variable.

Although embodiments of the invention and its advantages have been described above, it should be understood that various changes, substitutions and alterations can be made herein without departing from the scope of the invention.

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## Claims

1. A method for monitoring and/or controlling the efficiency of an organization comprising steps of:
  - 55 determining a plurality of performance variables relating to the performance of the organization which together characterize the efficiency of the organization;
  - determining a plurality of time intervals during which to accumulate performance variable data;
  - constructing at least one interaction table that contains an expected change in each performance variable when at least one other performance variable changes;

collecting performance variable data for a most recent time interval;  
 calculating a most recent efficiency rating said the most recent time interval using said performance variable data;  
 determining the relative impact of each performance variable on the efficiency rating for said most recent time interval; and  
 modifying selected ones of said performance variables to increase the value of said most recent time interval.

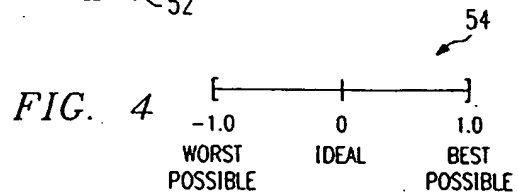
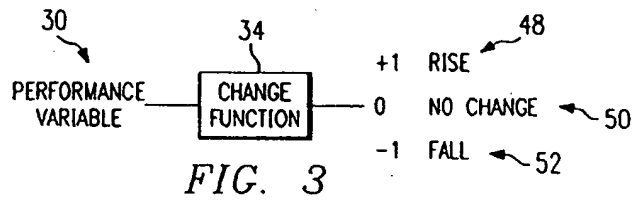
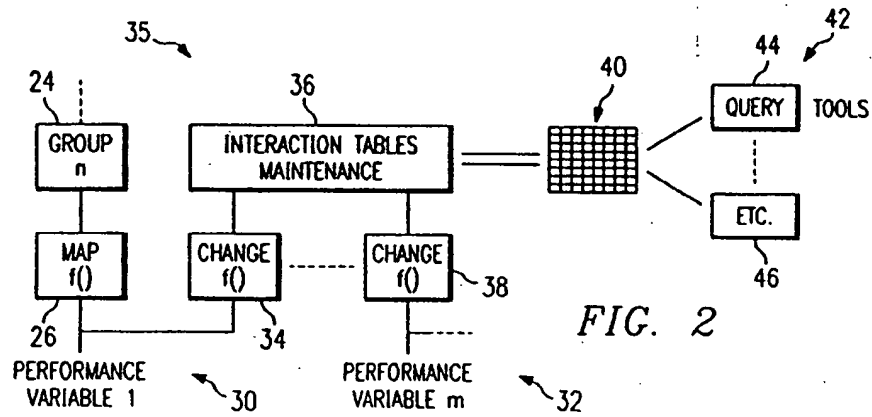
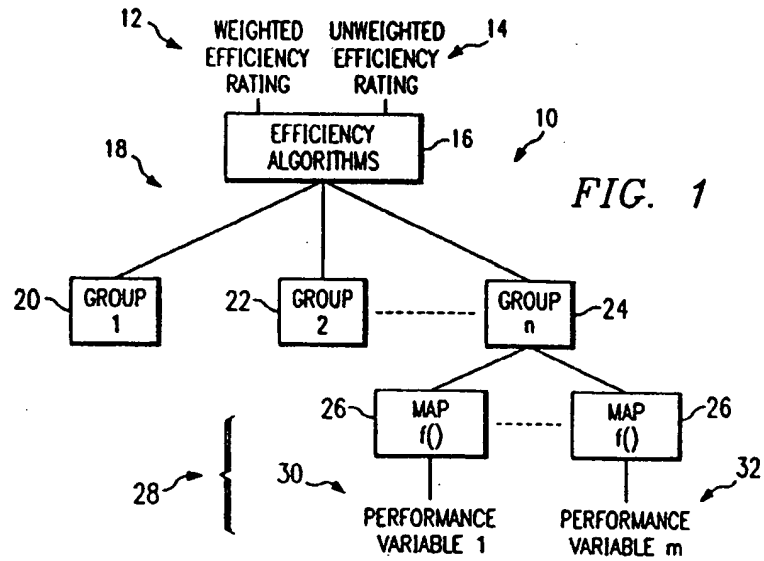
2. A method for monitoring and/or controlling the efficiency of an organization comprising steps of:
  - defining a plurality of performance variables associated with the organization, said performance variables being further associated with a measurable property of the organization;
  - mapping each of said plurality of performance variables to a normalized performance variable having a neutral value and at least one inflection point within a normalized range of values, said inflection point describing varying effects of said normalized performance variable on the organization's efficiency;
  - assigning a weighting factor to each of said normalized performance variables to produce a plurality of weighted normalized performance variables, said weighting factor relating to the importance of each of said normalized performance variables to the efficiency of the organization; and
  - determining the efficiency of the organization as a function of said plurality of weighted normalized performance variables.
3. A method according to claim 1 or claim 2, further comprising a step of mapping a variable within a performance range having at least one good value and at least one bad value.
4. A method according to any one of the preceding claims, further comprising a step of normalizing said plurality of performance variables for comparing uncommon raw data values among one another.
5. A method according to any one of the preceding claims, wherein comprising a step of calculating the efficiency of an individual portion of an organizational group within an organization.
6. A method according to any one of the preceding claims, further comprising a step of transforming at least one external event into a performance variable for determining the effect on the organizations efficiency of a change and the external variable.
7. A method according to any one of the preceding claims comprising steps of:
  - defining a plurality of performance variables associated with a group within the organization, said performance variables being further associated with a measurable property of the organization;
  - mapping each of said plurality of performance variables to a normalized performance variable according to a neutral value and at least one inflection point of said performance variable within a normalized range of values, said inflection point describing varying effects of said normalized performance variable on the organization's efficiency;
  - assigning a weighting factor to each of said normalized performance variables to produce a plurality of weighted normalized performance variables, said weighting factor relating to the importance of each of said normalized performance variables to the efficiency of the organization;
  - determining the interactions among said weighted normalized performance variables;
  - recording said interaction between said weighted normalized performance variables in an interaction table, said interaction table comprising a plurality of values, each of said values being for associating said weighted normalized performance variables among one another.
8. A method according to claim 7, wherein said interaction recording step further comprises a step of recording in a first interaction table an entry for each performance variable that reflects whether the performance variable is expected to increase or decrease when another variable increases and all other performance variables remain constant.
9. A method according to claim 7 or claim 8, further comprising a step of automatically recording said interactions between the performance variables and/or a step of uniquely defining the format and content of the interaction tables and/or a step of automatically establishing the format and content of the interaction tables.
10. A method according to any one of claims 7 to 9, wherein said interaction recording step further comprises

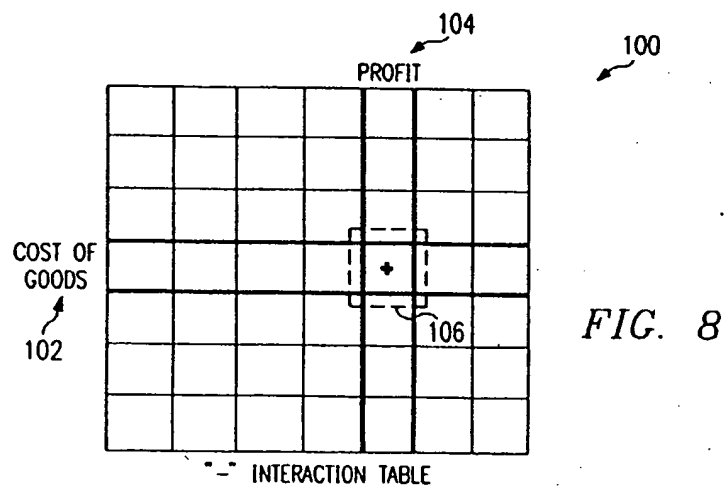
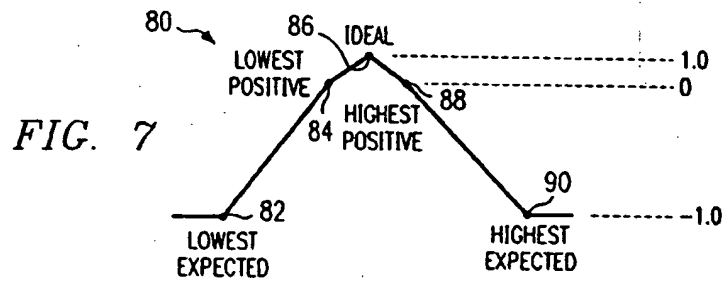
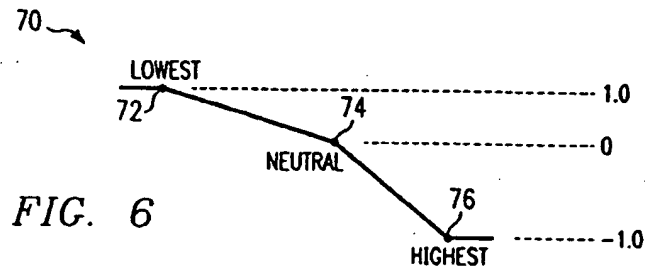
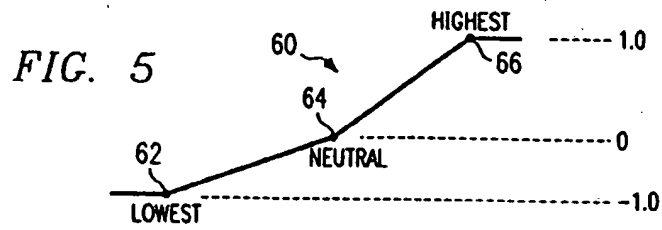
a step of storing actually measured performance variables for indicating the actual performance of an organization.

- 5 11. A system for monitoring and/or controlling the efficiency of an organization comprising:

  - means for determining a plurality of performance variables relating to the performance of the organization which together characterize the efficiency of the organization;
  - means for determining a plurality of time intervals during which to accumulate performance variable data;
  - means for constructing at least one interaction table that contains an expected change in each performance variable when at least one other performance variable changes;
  - 10 means for collecting performance variable data for a most recent time interval;
  - means for calculating a most recent efficiency rating said the most recent time interval using said performance variable data;
  - means for determining the relative impact of each performance variable on the efficiency rating for said most recent time interval; and
  - 15 means for modifying selected ones of said performance variables to increase the value of said most recent time interval.
- 20 12. A system for monitoring and/or controlling the efficiency of an organization, comprising:

  - a plurality of performance variables for defining measurable properties associated with the organization;
  - mapping means defining a set of mappings for mapping each of said plurality of performance variables to a normalized performance variable according to a neutral value and at least one inflection point of said performance variable within a normalized range of values, said inflection point describing varying effects of said normalized performance variable;
  - 25 weighting means defining a plurality of weighting factors for assigning to each of said normalized performance variables for generating a weighted normalized performance variable, said weighting factors relating to a predicted importance of each of said normalized performance variables to the efficiency of the organization; and
  - 30 efficiency calculating means for calculating the efficiency of the organization as a function of said weighted normalized performance variables.





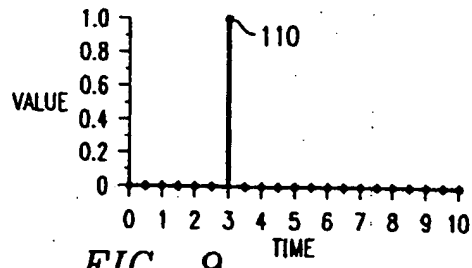


FIG. 9

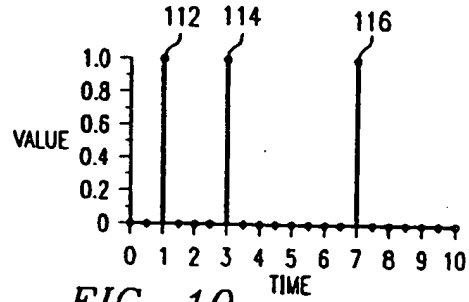


FIG. 10

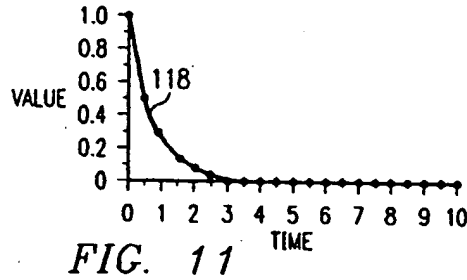


FIG. 11

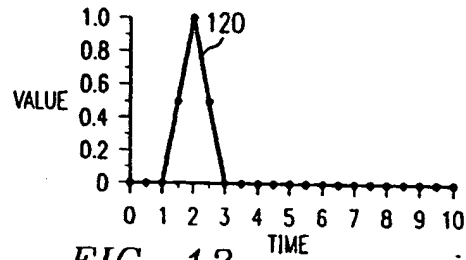


FIG. 12

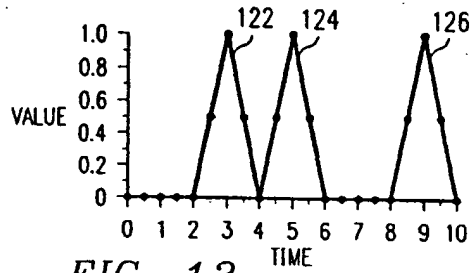
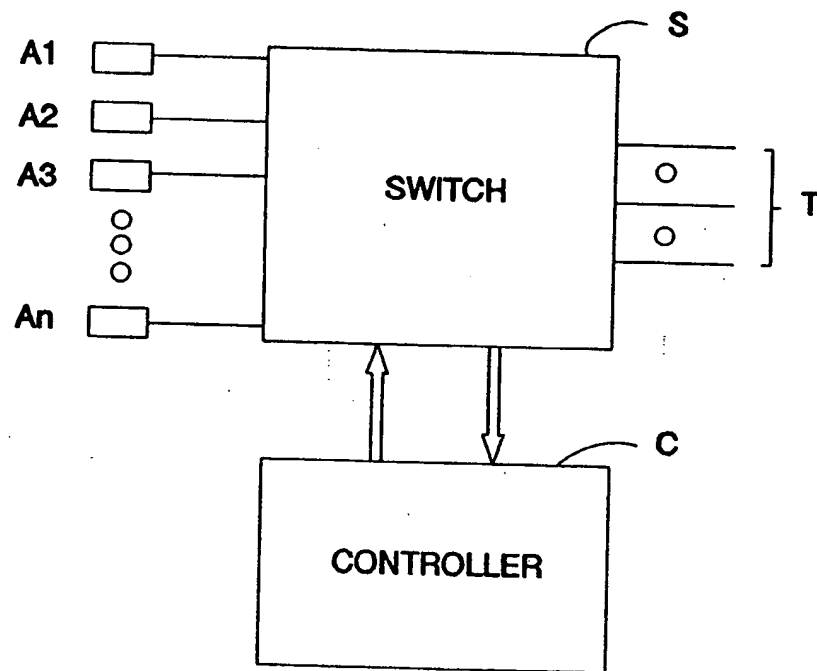


FIG. 13



**FIG. 14**

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